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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Paul Silinger, et al.

Application No.: 10/765782 Group No.: 1753
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For: INTERNAL HEAT SPREADER PLATING METHODS AND DEVICES

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Enclosed please find the certified copy of the EP Application No. 02707865.8 from which priority is claimed for this case:

Application Number: 10/765782
Filing Date: January 26, 2004

Date: June 8, 2004

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CERTIFICATE

It is herewith certified that the attached document is a true copy of the original document contained in European patent application

02707865.8

The above mentioned European patent application derives from international application PCT/US02/05536 which was filed on 21.02.02 and published under international publication number WO 02/070144 on 12.09.02.

The date of filing, 21.02.02, is maintained for the European patent application.

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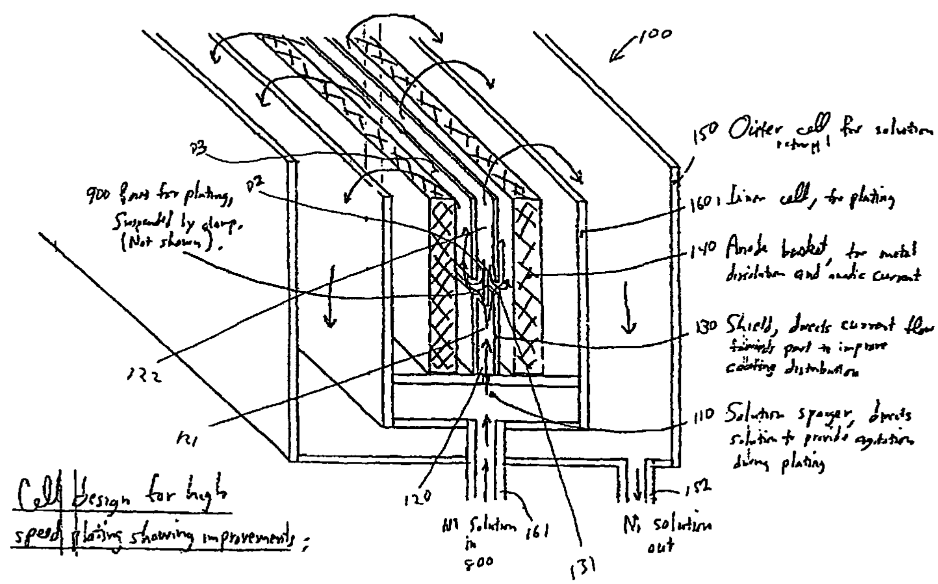
(54) Title: INTERNAL HEAT SPREADER PLATING METHODS AND DEVICES



(57) Abstract: An improved method and plating system (100) comprising a plurality of non-electrically conductive shields (130) forming an elongated upper channel (122) and an elongated lower channel (121); a plating solution sparger comprising a series of inlets oriented to direct any plating solution flowing through the inlets into the lower channel and towards the upper channel; a plurality of anodes positioned outside and along the length of the upper and lower channels; said method comprising submerging a workpiece (900) in the plating solution; positioning the workpiece at least partially within the channels, and causing electrical current to flow between the anodes the workpiece moving along the channel lengths.

WO 02/070144 A1

— *with amended claims*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNAL HEAT SPREADER PLATING METHODS AND DEVICES

This application claims the benefit of U.S. provisional application number 60/272805 incorporated herein by reference in its entirety.

Field of The Invention

The field of the invention is methods of plating heat spreaders and other parts designed for thermal management of semiconductor devices.

Background of The Invention

A common continuous plating system comprises an elongated plating chamber/cell and a movement mechanism designed to move parts along the length of the cell while the parts are being plated. The chamber is sufficiently long so that the plating of a part which enters the chamber at one end and exits at the other can be completed by the time the part traverses the length of the chamber.

Referring to figure 1A, previously known plating systems such as the MP 300 available from Technic Inc. utilize vertical solution spargers 11 to introduce plating solution 80 into the plating compartment 12 and to direct the incoming solution 80 towards the parts 90 being plated. Known systems also use electrically insulating shields 13 to manipulate the flow of current between the cathode/part 90 and one or more anode baskets 14. As shown in figure 1, the distance D1 between the shields 13 and the part being plated 90 is sufficiently great so as to allow the part 90 to be moved between vertical spargers 11 which are placed between the part 90 and the shields 13. Systems similar to those of figure 1 are typically used to plate a single edge 91 of a printed circuit board 90 with the edge being plated 91 being submerged in the plating solution 80 and the opposite edge 92 being positioned out of the plating solution 80. Systems similar to those of figure 1 typically comprise an inner cell 15 used for plating, an outer cell 16 for solution return, one or more fluid inlets 15A and one or more fluid outlets 16A. Fluid typically enters inner cell 15 via fluid inlet 15A, flows out of inner cell 15 and into outer cell 16, and then flows out of out cell 16 via fluid outlet 16A.

Unfortunately, whether previously recognized or not, systems similar to those of figure 1 do not always provide optimum metal distribution over a work piece. As such, there is a need for plating systems having improved metal distribution.

Summary of the Invention

The present invention is directed to improved plating systems and methods such as an improved plating system comprising an elongated upper channel and an elongated lower channel, and a plating solution sparger comprising a series of inlets oriented to direct any plating solution flowing through the inlets into the lower channel and towards the upper channel. A preferred embodiment of such a system comprises a plurality of electrically insulating shields forming an elongated upper channel and an elongated lower channel, the upper and lower channels each having a width less than or equal to one inch; a plurality of part holding clamps electrically coupled to a power source and positioned within the upper channel or the lower channel; a plating solution sparger comprising a series of inlets oriented to direct any plating solution flowing through the inlets into the lower channel and towards the upper channel; and a plurality of anodes positioned outside and along the length of the upper and lower channels.

An improved method of plating a work piece comprises: submerging a work piece to be plated in a volume of plating solution; positioning a work piece to be plated at least partially within an upper plating channel and a lower plating channel, the upper and lower plating channels comprising non electrically conductive sides, the channels being positioned opposite each other and being separated from each other, the separation between the channels forming a pair of solution egress slots positioned approximately over the center of the work piece to be plated; causing electrical current to flow between the work piece and one or more anodes, the current flow passing through the solution egress slots; and moving the work piece to be plated along the length of the plating channels to form one or more internal heat spreaders on a surface of the work piece which is essentially parallel to the shields.

It is contemplated that the deposition rate can be greatly increased via the more turbulent solution flow and less cathode-anode restriction found in the systems described herein.

It is contemplated that the use of the plating system described herein to plate the workpieces results in more uniformity in plating between work pieces and less overplating as a result of each part being positioned at the same depth within the cell and having the same shield distribution.

It is contemplated that the methods and devices described herein are particularly suitable for plating entire surfaces of discrete parts, and, more particularly, for plating internal heat spreaders (IHS) or other parts designed for thermal management of semiconductor devices.

Various objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of preferred embodiments of the invention, along with the accompanying drawings in which like numerals represent like components.

Brief Description of The Drawings

Fig. 1 is a perspective view of a prior art plating system.

Fig. 2 is a perspective view of a plating system embodying the invention.

Fig. 2A is a detailed view of a part being plated in the system of Fig. 2.

Fig. 3A is a top view of a clip suitable for use in the system of Fig. 1.

Fig. 3B is a top view of a clip suitable for use in the system of Fig. 2.

Fig. 4 is a schematic of a method embodying the invention.

Detailed Description

An improved plating system 100 is shown in figure 2 which provides for improved metal distribution over a work piece 900. In the improved system 100, the vertical spargers (spargers 11 in figure 1) found in prior art plating systems are eliminated and fluid 800 enters the chamber 120 through the bottom of the chamber with the bottom of the chamber acting as a horizontal sparger 110. By eliminating the vertical spargers, the distance D2 between the part being plated 900 and the shields 130 can be decreased (with a corresponding decrease in the distance D4 between the fields forming the sides of the channel). It is preferred that the distance D2 between the part being plated 900 and the shields 130 be less than or equal to one inch, or, more preferably, less than or equal to 0.5 inches.

The system of figure 2 may be obtained by modifying the system of figure 1 (a Technic Inc. MP 300) in the following manner: (1) eliminating the tubular vertical solution spargers and replacing them with holes 111 fabricated in the lower plenum so that solution travels around the parts to be plated as a turbulent flow from the bottom of the parts to the tops, and not from the sides; (2) increasing the solution velocity; (3) moving the shields closer to the parts to be plated (cathodes); (4) incorporating part holding clamps sufficiently narrow so as to adequately hold the part while still permitting the claims and parts to move between the shields; and (5) incorporating a double rinsing and drying process where the plating/part holding fixture is rinsed and dried first, and the plated part and lower half of the fixture are subsequently rinsed and dried.

It is contemplated that the use of one or more horizontal spargers 110 having holes/inlets 111 and being located at an end of a chamber 120 at least partially formed by an upper channel 122 and lower channel 121 to direct fluid flow through a first of the channels and towards a second channel so that it flows toward a part 900 positioned relative to a gap 131 between the channels as shown in figures 2 and 2A will provide for more turbulent fluid flow and a corresponding higher deposition rate. In order to obtain the desired turbulence, it is preferred that the distance D5 between the upper and lower channels (the width of gaps 131) be as low as 20 percent of the height D6 of work piece 900.

In essence, the shields 130 of figure 2 form narrow upper and lower plating channels (121 and 122) through which the parts being plated move with each part 900 having one edge 902 positioned within the upper plating channel 122 and an opposite edge 901 positioned within the lower plating channel 121. Because the shields 130 are electrically insulating, current flow between the work piece 900 and the anode baskets 140 is forced to pass through the gaps 131 between the upper and lower shields. Positioning and movement of a part 900 within channel 120 is accomplished by clipping part 900 to a clip 170 and moving clip 170.

Figure 3A shows the original design of the part holding clamps/clips 170A utilized by the system of figure 1 while figure 3B shows an improved clip 170 for use in the system of figure 2. It should be noted that the clamp design has been modified to permit the distance D2 between the shields and a work piece being held by the clamps to be decreased to 0.5 inches or less by decreasing the thickness D5 of clip 170.

It is contemplated that shielding the work piece/cathode of a plating system by moving the work piece within narrow channels formed by the shield rather than using the shields to shield the anodes by moving the shields closer to the anodes than to the parts being plated results in better distribution of deposited metal on the work pieces. As such, it contemplated that the distance D3 between the shields 130 and the anodes 140 be greater than the distance D2 between a part being plated 900 and the shields 130.

A method 1000 of using the system of figure 2 may include (see figure 4) the following steps: step 1010, submerging a work piece 900 to be plated in a volume of plating solution 800; step 1020, positioning the work piece to be plated 900 at least partially within an upper plating channel 122 and a lower plating channel 121, the upper and lower plating channels comprising non electrically conductive sides (shields 130), the channels 121 and 122 being positioned opposite each other and being separated from each other, the separation between the channels forming a pair of solution egress slots 131 positioned approximately over the center of the work piece 900 to be plated; step 1030, causing electrical current to flow between the work piece 900 and one or more anodes 140, the current flow passing through the solution egress slots 131; and step 1040, moving the work piece 900 to be plated along the length of the plating channels 121 and 122 to form an electrodeposited layer on one or more internal heat spreaders (911, 921). The surface (910, 920) of the work piece 900 is essentially parallel to the shields 130 during this operation.

The forgoing method may further comprise one or more of the following steps: step 1005, coupling the work piece to a frame adapted to hold and move the work piece during plating; step 1050, after plating, performing a first rinse and dry cycle wherein at least a portion of the frame is rinsed and dried while the work piece is kept damp; and step 1060, after the first rinse and dry cycle, performing a second rinse and dry cycle wherein the work piece is removed from inner cell 150 and rinsed and dried. It is contemplated that the use of such a two step process wherein the frame is dried first will result in stain free drying of the work piece bacause potentially contaminated rinsewater from the clip is not allowed to redeposit onto and/or stain the workpiece.

The following steps may also prove advantageous when used in the foregoing method: a) rinsing the workpiece/part and clip with clean water; b) drying only the clip without regard

for staining; c) rinsing the part only with ultra pure water, while keeping the clip dry; d) drying the part. This drying method prevents the possibility contaminated rinsewater from the clips splashing onto the parts during drying causing staining of the heat spreaders.

Variations of this method may include the use of channels having a width of one inch or less and/or including a step of adjusting the width of the slots 131 between the channels to obtain an optimum or at least more uniform plating distribution on the work piece 900.

In preferred embodiments, horizontal sparger 110 will be sized adequately to provide turbulent flow within the channel. Care must be taken to allow sufficient drainage such that the cell does not want to overflow. It is also difficult to achieve turbulent flow over the submerged portion of the clip while not allowing any splashing of the plating fluid onto the portion of the clips above the cell. Any solution that is splashed onto the clips contributes to the previously mentioned rinse-dry concerns.

Chamber 120 is preferred to allow for turbulent flow across the work piece while minimizing surface splashing. This is generally achieved by designing a discharge plenum (horizontal sparger 110) with a series of holes with a given diameter. These holes are drilled in such a manner to direct fluid toward the part contained within the clip. Plating solution is pumped through this plenum through a valve style restrictor, and this valve is adjusted to achieve the maximum flow without causing splashing at the surface of the plating solution. The distance between the discharge plenum and the part, the hole diameter of the discharge plenum and the flow rate through the plenum are all set to maximize turbulent flow at the workpiece while minimizing splashing at the solution surface.

Shields 120 preferably comprise a sheet of electrically insulating material in which a slot has been machined to allow current flow, the slot being centered on the part to be plated. The length of the slot should coincide with the length of the anode from which electrical current is being restricted, and the height of the slot is selected to provide the best metal distribution on the electroplated component. Empirically, a slot of about ¼" allows ample current for plating of a square heat spreader 1 ¼" on a side. In this example, the shield was moved to within ½" of the clip containing the part for plating.

In preferred embodiments, the solution velocity will be such that it is clearly within the region for turbulent flow. This is important in order to replenish plating electrolyte at the work surface, which is necessary to increase metallic deposition rate. Using the cell described above, deposition rates exceeding 2 microns/minute have been achieved when depositing nickel from sulfamate based electrolyte.

It is contemplated that system 100 is particularly well adapted for use with a metal electrolyte designed to deposit 800 one or more of the following metals: Ni, Au, Ag, Sn, Cu, Pb, In, Bi or alloys of these.

It is contemplated that system 100 may be advantageously used where work piece 900 comprises is one or more copper heat spreaders specifically designed to remove or dissipate heat from semiconductor devices. Althernately, the copper may be replaced with Aluminum, Aluminum-Silicon alloy, kovar alloy 42 or alloys thereof.

Use of the preferred system and or method is contemplated to result in deposition rates of at least 2 microns/minute while maintaining a uniform distribution of metal such that the thickness of the deposited metal varies by less than 1 micron over the surface of the work piece being plated. Sample 31 mm square heat spreaders electroplated with about 4 microns of nickel had a film uniformity of 3.5 microns to 4.5 microns across the part. Identical parts plated without the optimized shielding approach were typically 3 microns at the low point to over 6 microns at the high points.

Thus, specific embodiments and applications of an improved plating system have been disclosed. It should be apparent, however, to those skilled in the art that many more modifications besides those already described are possible without departing from the inventive concepts herein. The inventive subject matter, therefore, is not to be restricted except in the spirit of the appended claims. Moreover, in interpreting both the specification and the claims, all terms should be interpreted in the broadest possible manner consistent with the context. In particular, the terms "comprises" and "comprising" should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced.

CLAIMS

What is claimed is:

1. A plating system comprising:
an elongated upper channel and an elongated lower channel; and
a plating solution sparger comprising a series of inlets oriented to direct any plating solution flowing through the inlets into one and towards another of the upper and lower channels.

2. The system of claim 1 further comprising:
an anode; and
a substantially planar cathode comprising a first surface conductive surface, a second conductive surface, and a perimeter edge, the first conductive surface and second conductive surfaces being substantially parallel to each other and positioned on opposite sides of the cathode; wherein
the sparger is positioned at least as close to the perimeter edge of the cathode as to either of the first or second conducting surfaces.

3. The system of claim 2 wherein the sparger directs any plating solution flowing through the inlets towards the cathode in a plane substantially coplanar with the cathode.

4. The system of claim 3 wherein:
each of the upper and lower channels comprises two substantially planar and parallel non electrically conductive sides that are substantially parallel to the cathode; and
the cathode is positioned at least partially within each of the upper and lower channels between the non electrically conductive sides.

5. The system of claim 4 wherein:
the upper and lower channels are positioned opposite each other and are separated from each other, the separation between the channels forming a pair of solution egress slots; and

the channels are adapted to prevent current from flow between the anode and cathode other than through the egress slots.

6. The system of claim 5 wherein the egress slots are positioned approximately parallel to a center line of the cathode.

7. The system of claim 6 wherein the cathode comprises a dielectric substrate and the conductive surfaces are adapted to promote the formation of heat spreaders on the dielectric substrate.

8. The system of claim 1 wherein each of the upper channel and lower channel have a width less than or equal to one inch.

9. The system of claim 1 wherein the sparger is positioned horizontally and directs any plating solution flowing through the inlets into the lower channel and towards the upper channel.

10. The system of claim 1 wherein each of the upper channel and lower channel have a width less than or equal to 0.5 inches.

11. The system of claim 1 wherein each of the upper channel and lower channel have a width less than or equal to 0.5 inches, and the further comprising a plurality of part holding clamps electrically coupled to a power source and positioned within the upper channel or the lower channel.

12. The system of claim 1 further comprising a plurality of anodes positioned outside and along the length of the upper and lower channels.

13. The system of claim 1 wherein the upper channel and lower channel are separated by a distance and at least one of the upper channel and lower channel are adapted to be moved to vary the distance.

14. The system of claim 1 wherein the shortest distance from a part being plated to a channel wall is less than the shortest distance between the channel wall and an anode.

15. A plating system comprising:

an anode, a planar cathode, a sparger, and a plurality of electrically insulating shields; wherein

each of the plurality of shields is positioned between the anode and the cathode but not between the sparger and the cathode, and each of the plurality of shields is approximately co-planar with one of two reference planes that are substantially parallel to the cathode; and

the sparger is adapted to direct plating fluid toward and edge of the cathode along in a plane substantially co-planar with cathode.

16. A method of plating a work piece comprising:

submerging a work piece to be plated in a volume of plating solution;

positioning a work piece to be plated at least partially within an upper plating channel and a lower plating channel, the upper and lower plating channels comprising non electrically conductive sides, the channels being positioned opposite each other and being separated from each other, the separation between the channels forming a pair of solution egress slots positioned approximately over the center of the work piece to be plated;

causing electrical current to flow between the work piece and one or more anodes, the current flowing into the upper and lower channels only after passing through the solution egress slots; and

moving the work piece to be plated along the length of the plating channels to form one or more internal heat spreaders on a surface of the work piece which is essentially parallel to the shields.

17. The method of 16 further comprising:

coupling the work piece to a frame adapted to hold and move the work piece during plating;

after plating, performing a first rinse and dry cycle wherein at least a portion of the frame is rinsed and dried while the work piece is kept damp;

after the first rinse and dry cycle, performing a second rinse and dry cycle wherein the work piece is rinsed and dried.

18. The method of claim 17 wherein water is used in the first and second rinse cycles, and the second rinse cycle utilizes water having fewer impurities than that used in the first rinse cycle.

AMENDED CLAIMS

[Received by the International Bureau on 22 July 2002 (22.07.02): original claims 1-18 replaced by amended claims 1-18 (4 pages)]

What is claimed is:

1. A plating system comprising:
at least two anodes;
an elongated upper channel and an elongated lower channel, each of the upper and lower channels positioned between the at least two anodes and each of the channels comprising at least two insulating sides; and
a plating solution sparger comprising a series of inlets oriented to direct any plating solution flowing through the inlets into one and towards another of the upper and lower channels.

2. A plating system comprising:
an elongated upper channel and an elongated lower channel;
a plating solution sparger comprising a series of inlets oriented to direct any plating solution flowing through the inlets into one and towards another of the upper and lower channels;
an anode; and
a substantially planar cathode comprising a first surface conductive surface, a second conductive surface, and a perimeter edge, the first conductive surface and second conductive surfaces being substantially parallel to each other and positioned on opposite sides of the cathode; wherein
the sparger is positioned at least as close to the perimeter edge of the cathode as to either of the first or second conducting surfaces.

3. The system of claim 2 wherein the sparger directs any plating solution flowing through the inlets towards the cathode in a plane substantially coplanar with the cathode.

4. The system of claim 3 wherein:
each of the upper and lower channels comprises two substantially planar and parallel non electrically conductive sides that are substantially parallel to the cathode; and
the cathode is positioned at least partially within each of the upper and lower channels between the non electrically conductive sides.

5. The system of claim 4 wherein:

the upper and lower channels are positioned opposite each other and are separated from each other, the separation between the channels forming a pair of solution egress slots; and

the channels are adapted to prevent current from flow between the anode and cathode other than through the egress slots.

6. The system of claim 5 wherein the egress slots are positioned approximately parallel to a center line of the cathode.

7. The system of claim 6 wherein the cathode comprises a dielectric substrate and the conductive surfaces are adapted to promote the formation of heat spreaders on the dielectric substrate.

8. The system of claim 1 wherein each of the upper channel and lower channel have a width less than or equal to one inch.

9. The system of claim 1 wherein the sparger is positioned horizontally and directs any plating solution flowing through the inlets into the lower channel and towards the upper channel.

10. The system of claim 1 wherein each of the upper channel and lower channel have a width less than or equal to 0.5 inches.

11. The system of claim 1 wherein each of the upper channel and lower channel have a width less than or equal to 0.5 inches, and the further comprising a plurality of part holding clamps electrically coupled to a power source and positioned within the upper channel or the lower channel.

12. The system of claim 1 further comprising a plurality of anodes positioned outside and along the length of the upper and lower channels.

13. The system of claim 1 wherein the upper channel and lower channel are separated by a distance and at least one of the upper channel and lower channel are adapted to be moved to vary the distance.

14. The system of claim 1 wherein the shortest distance from a part being plated to a channel wall is less than the shortest distance between the channel wall and an anode.

15. A plating system comprising:

an anode, a planar cathode, a sparger, and a plurality of electrically insulating shields; wherein

each of the plurality of shields is positioned between the anode and the cathode but not between the sparger and the cathode, and each of the plurality of shields is approximately co-planar with one of two reference planes that are substantially parallel to the cathode; and

the sparger is adapted to direct plating fluid toward an edge of the cathode in a plane substantially co-planar with the cathode.

16. A method of plating a work piece comprising:

submerging a work piece to be plated in a volume of plating solution;

positioning a work piece to be plated at least partially within an upper plating channel and a lower plating channel, the upper and lower plating channels comprising non electrically conductive sides, the channels being positioned opposite each other and being separated from each other, the separation between the channels forming a pair of solution egress slots positioned approximately over the center of the work piece to be plated;

causing electrical current to flow between the work piece and one or more anodes, the current flowing into the upper and lower channels only after passing through the solution egress slots; and

moving the work piece to be plated along the length of the plating channels to form one or more internal heat spreaders on a surface of the work piece which is essentially parallel to the shields.

17. The method of 16 further comprising:

coupling the work piece to a frame adapted to hold and move the work piece during plating;

after plating, performing a first rinse and dry cycle wherein at least a portion of the frame is rinsed and dried while the work piece is kept damp;

after the first rinse and dry cycle, performing a second rinse and dry cycle wherein the work piece is rinsed and dried.

18. The method of claim 17 wherein water is used in the first and second rinse cycles, and the second rinse cycle utilizes water having fewer impurities than that used in the first rinse cycle.

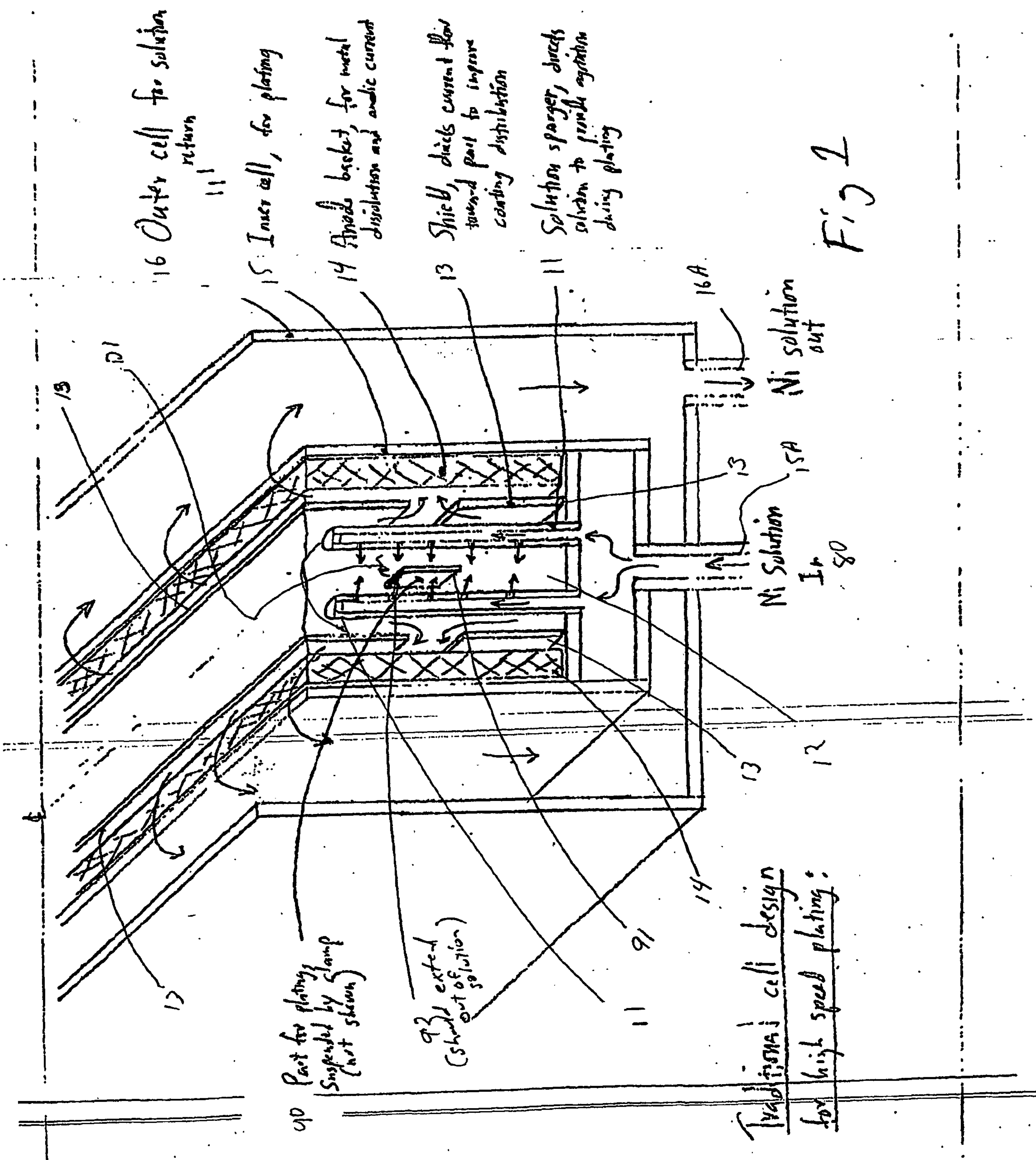

16 Outer cell for solution return
11'
15 Inner cell, for plating
14 Anode basket, for metal dissolution and anodic current
13 Shield, directs current flow toward part to improve coating distribution
11 Solution sparger, directs solution to provide agitation during plating
16A
Ni solution out
15A
13
Ni Solution In
80
12
13
14
91
11
10
13
90 Part for plating Suspended by clamp (not shown)
92 (should extend out of solution)
Traditional cell design for high speed plating:

Fig 1

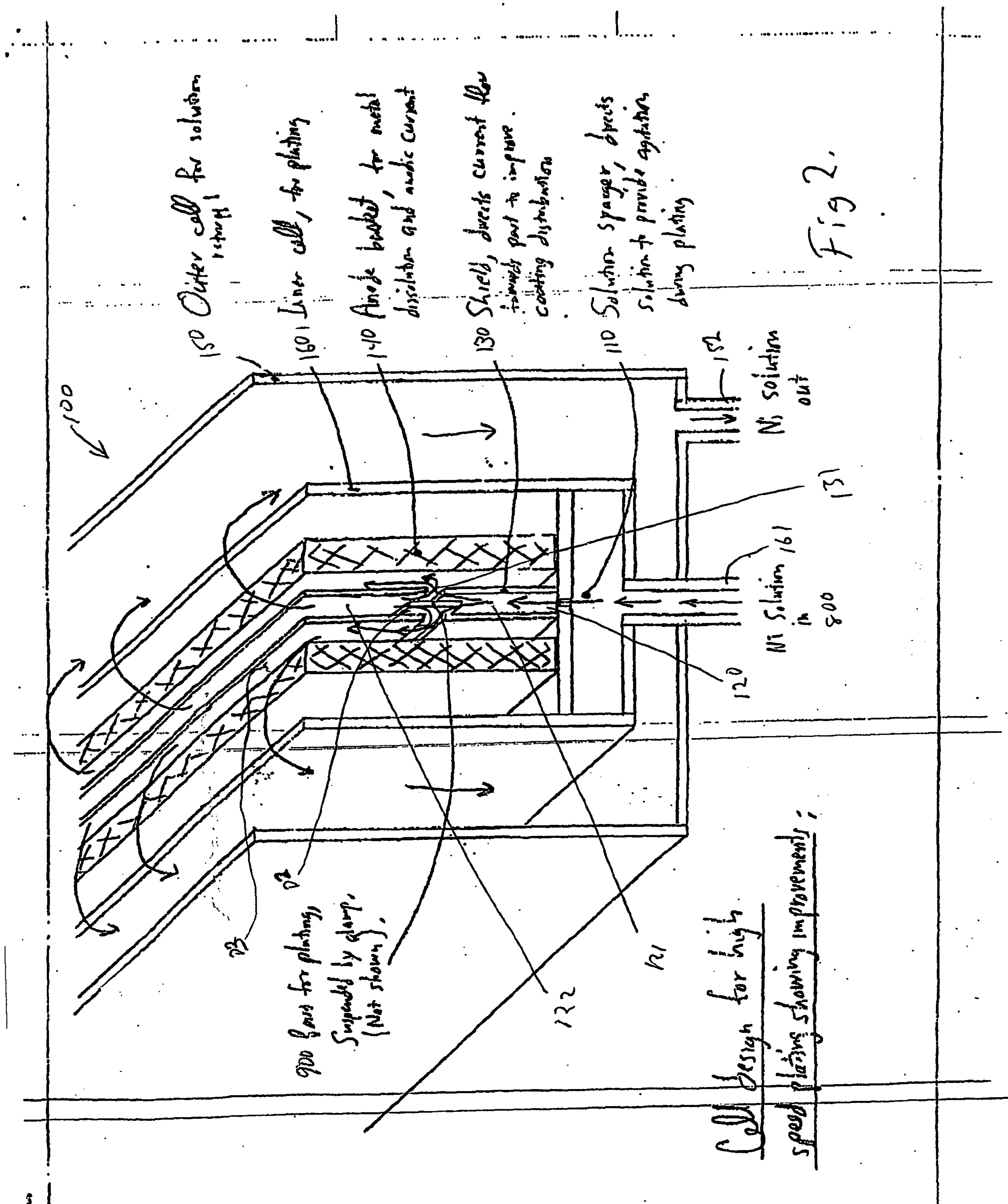

150 Outer cell for solution return!
160 Inner cell, for plating
140 Anode basket, for metal dissolution and anodic current
130 Shield, directs current flow towards part to improve coating distribution
110 Solution Sparger, directs solution to provide agitation during plating
100
152
Ni Solution out
131
161
Ni Solution in
800
120
121
122
23
22
900 Part for plating, Suspended by clamp, (Not shown).
Cell Design for high speed plating showing improvements;

Fig 2.

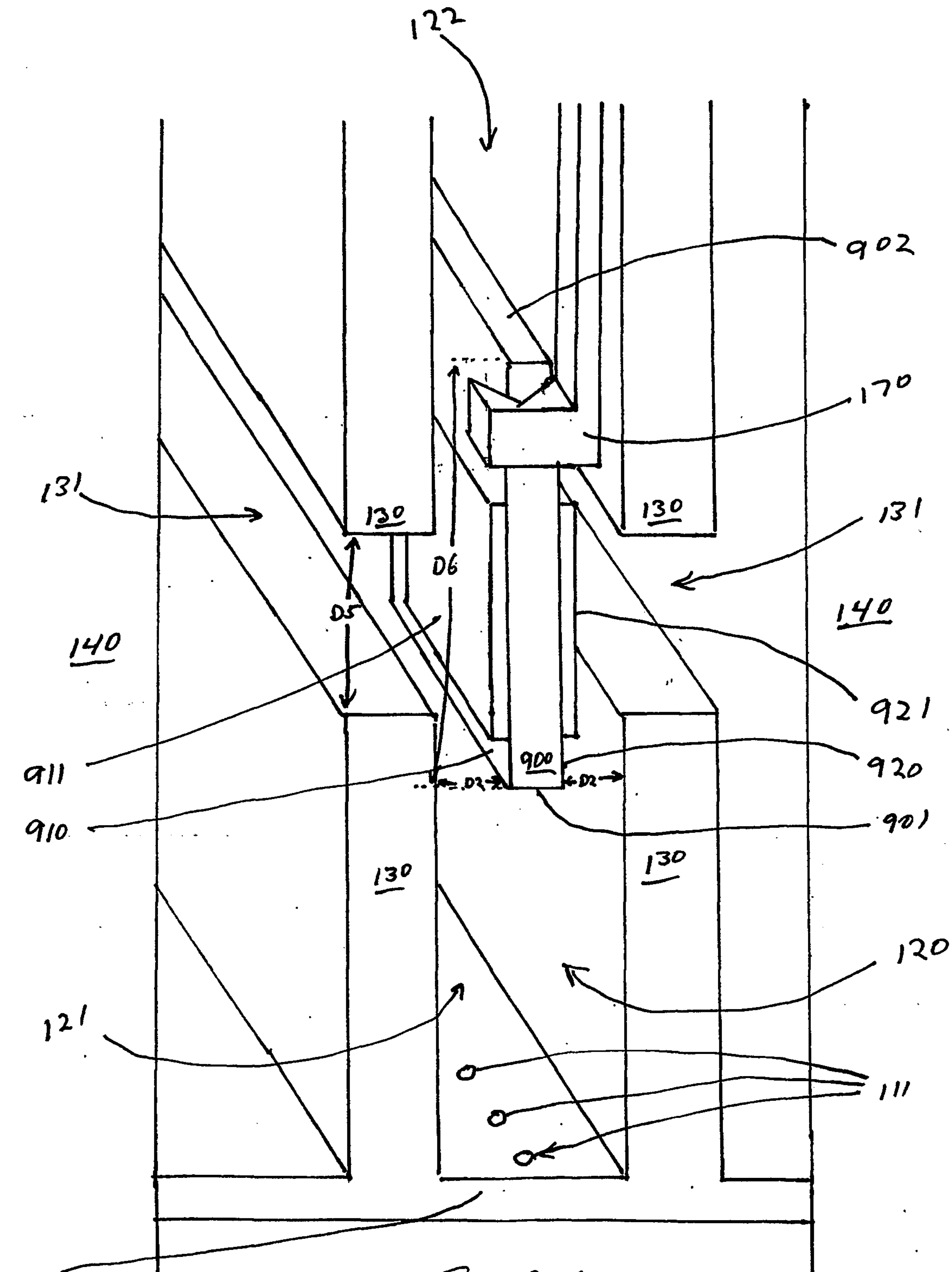

122
902
170
131
130
130
131
D6
D5
140
140
921
911
900
920
D2
D2
910
901
130
130
120
121
111
110

Fig. 2A

IMPROVED CLAMP DESIGN

1. ORIGINAL DESIGN

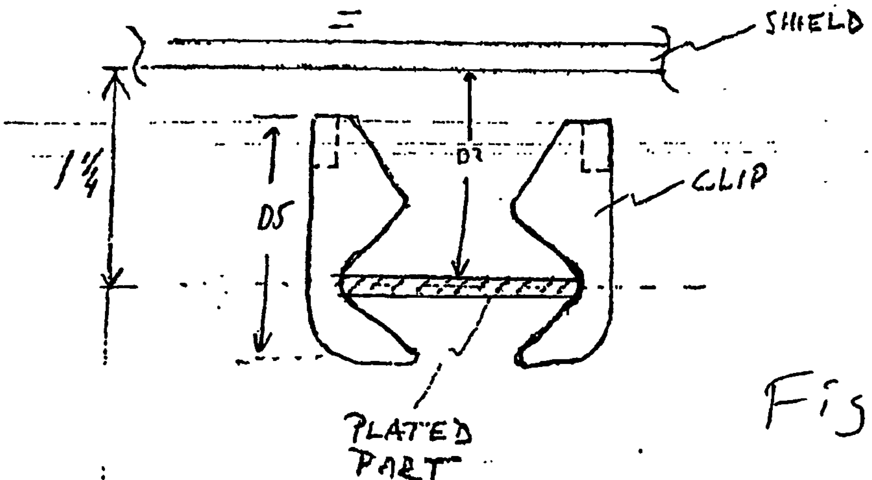


Fig. 3A

2. IMPROVED DESIGN (SHIELD DISTANCE REDUCED FROM 1.25" TO 0.5")

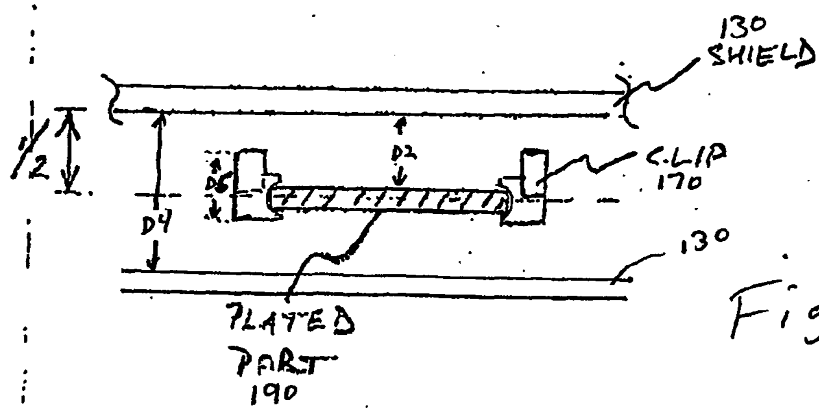


Fig. 3B

2/28/01 PS

1005
coupling a work piece to a frame adapted to hold and move the work piece during plating

1010
submerging the work piece to be plated in a volume of plating solution

1020
positioning the work piece to be plated at least partially within an upper plating channel and a lower plating channel, the upper and lower plating channels comprising non electrically conductive sides, the channels being positioned opposite each other and being separated from each other, the separation between the channels forming a pair of solution egress slots positioned approximately over the center of the work piece to be plated

1030
causing electrical current to flow between the work piece and one or more anodes, the current flow passing through the solution egress slots

1040
moving the work piece to be plated along the length of the plating channels to form one or more internal heat spreaders on a surface of the work piece which is essentially parallel to the shields

1050
after plating, performing a first rinse and dry cycle wherein at least a portion of the frame is rinsed and dried while the work piece is kept damp

1060
after the first rinse and dry cycle, performing a second rinse and dry cycle wherein the work piece is removed from inner cell and rinsed and dried.

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/05536

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : B05C 3/00, 3/02; C25D 17/00, 5/00, 7/06
US CL : 118/410, 429; 204/273, 275.1; 205/137, 138;
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 118/410, 429; 204/206, 211, 273, 275.1; 205/137, 138;

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST: Sparger; electroplating, channels

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,372,825 A (EIDSCHUN) 08 February 1983, col. 3-4.	1, 8, 12
Y	US 4,772,371 A (LACE et al) 20 September 1988, Figures 2 and 3, col. 3, lines 35-68; col. 4 lines 32-68.	1, 12
Y	US 4,534,832 A (DOIRON, JR.) 13 August 1985, col. 3-4 and Figures.	1, 12-13
A	US 4,443,304 A (EIDSCHUN) 17 April 1984.	

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

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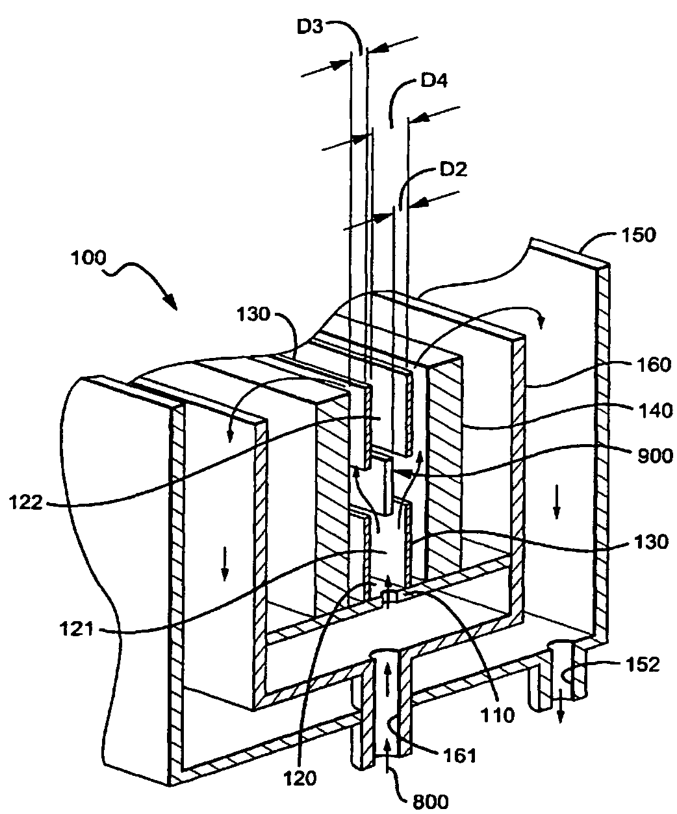
[Continued on next page]

(54) Title: INTERNAL HEAT SPREADER PLATING METHODS AND DEVICES



(57) Abstract: An improved method and plating system (100) comprising a plurality of non-electrically conductive shields (130) forming an elongated upper channel (122) and an elongated lower channel (121); a plating solution sparger comprising a series of inlets oriented to direct any plating solution flowing through the inlets into the lower channel and towards the upper channel; a plurality of anodes positioned outside and along the length of the upper and lower channels; said method comprising submerging a workpiece (900) in the plating solution; positioning the workpiece at least partially within the channels, and causing electrical current to flow between the anodes the workpiece moving along the channel lengths.

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INTERNAL HEAT SPREADER PLATING METHODS AND DEVICES

This application claims the benefit of U.S. provisional application number 60/272805 incorporated herein by reference in its entirety.

Field of The Invention

The field of the invention is methods of plating heat spreaders and other parts designed for thermal management of semiconductor devices.

Background of The Invention

A common continuous plating system comprises an elongated plating chamber/cell and a movement mechanism designed to move parts along the length of the cell while the parts are being plated. The chamber is sufficiently long so that the plating of a part which enters the chamber at one end and exits at the other can be completed by the time the part traverses the length of the chamber.

Referring to figure 1A, previously known plating systems such as the MP 300 available from Technic Inc. utilize vertical solution spargers 11 to introduce plating solution 80 into the plating compartment 12 and to direct the incoming solution 80 towards the parts 90 being plated. Known systems also use electrically insulating shields 13 to manipulate the flow of current between the cathode/part 90 and one or more anode baskets 14. As shown in figure 1, the distance D1 between the shields 13 and the part being plated 90 is sufficiently great so as to allow the part 90 to be moved between vertical spargers 11 which are placed between the part 90 and the shields 13. Systems similar to those of figure 1 are typically used to plate a single edge 91 of a printed circuit board 90 with the edge being plated 91 being submerged in the plating solution 80 and the opposite edge 92 being positioned out of the plating solution 80. Systems similar to those of figure 1 typically comprise an inner cell 15 used for plating, an outer cell 16 for solution return, one or more fluid inlets 15A and one or more fluid outlets 16A. Fluid typically enters inner cell 15 via fluid inlet 15A, flows out of inner cell 15 and into outer cell 16, and then flows out of out cell 16 via fluid outlet 16A.

Unfortunately, whether previously recognized or not, systems similar to those of figure 1 do not always provide optimum metal distribution over a work piece. As such, there is a need for plating systems having improved metal distribution.

Summary of the Invention

The present invention is directed to improved plating systems and methods such as an improved plating system comprising an elongated upper channel and an elongated lower channel, and a plating solution sparger comprising a series of inlets oriented to direct any plating solution flowing through the inlets into the lower channel and towards the upper channel. A preferred embodiment of such a system comprises a plurality of electrically insulating shields forming an elongated upper channel and an elongated lower channel, the upper and lower channels each having a width less than or equal to one inch; a plurality of part holding clamps electrically coupled to a power source and positioned within the upper channel or the lower channel; a plating solution sparger comprising a series of inlets oriented to direct any plating solution flowing through the inlets into the lower channel and towards the upper channel; and a plurality of anodes positioned outside and along the length of the upper and lower channels.

An improved method of plating a work piece comprises: submerging a work piece to be plated in a volume of plating solution; positioning a work piece to be plated at least partially within an upper plating channel and a lower plating channel, the upper and lower plating channels comprising non electrically conductive sides, the channels being positioned opposite each other and being separated from each other, the separation between the channels forming a pair of solution egress slots positioned approximately over the center of the work piece to be plated; causing electrical current to flow between the work piece and one or more anodes, the current flow passing through the solution egress slots; and moving the work piece to be plated along the length of the plating channels to form one or more internal heat spreaders on a surface of the work piece which is essentially parallel to the shields.

It is contemplated that the deposition rate can be greatly increased via the more turbulent solution flow and less cathode-anode restriction found in the systems described herein.

It is contemplated that the use of the plating system described herein to plate the workpieces results in more uniformity in plating between work pieces and less overplating as a result of each part being positioned at the same depth within the cell and having the same shield distribution.

It is contemplated that the methods and devices described herein are particularly suitable for plating entire surfaces of discrete parts, and, more particularly, for plating internal heat spreaders (IHS) or other parts designed for thermal management of semiconductor devices.

Various objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of preferred embodiments of the invention, along with the accompanying drawings in which like numerals represent like components.

Brief Description of The Drawings

Fig. 1 is a perspective view of a prior art plating system.

Fig. 2 is a perspective view of a plating system embodying the invention.

Fig. 2A is a detailed view of a part being plated in the system of Fig. 2.

Fig. 3A is a top view of a clip suitable for use in the system of Fig. 1.

Fig. 3B is a top view of a clip suitable for use in the system of Fig. 2.

Fig. 4 is a schematic of a method embodying the invention.

Detailed Description

An improved plating system 100 is shown in figure 2 which provides for improved metal distribution over a work piece 900. In the improved system 100, the vertical spargers (spargers 11 in figure 1) found in prior art plating systems are eliminated and fluid 800 enters the chamber 120 through the bottom of the chamber with the bottom of the chamber acting as a horizontal sparger 110. By eliminating the vertical spargers, the distance D2 between the part being plated 900 and the shields 130 can be decreased (with a corresponding decrease in the distance D4 between the fields forming the sides of the channel). It is preferred that the distance D2 between the part being plated 900 and the shields 130 be less than or equal to one inch, or, more preferably, less than or equal to 0.5 inches.

The system of figure 2 may be obtained by modifying the system of figure 1 (a Technic Inc. MP 300) in the following manner: (1) eliminating the tubular vertical solution spargers and replacing them with holes 111 fabricated in the lower plenum so that solution travels around the parts to be plated as a turbulent flow from the bottom of the parts to the tops, and not from the sides; (2) increasing the solution velocity; (3) moving the shields closer to the parts to be plated (cathodes); (4) incorporating part holding clamps sufficiently narrow so as to adequately hold the part while still permitting the claims and parts to move between the shields; and (5) incorporating a double rinsing and drying process where the plating/part holding fixture is rinsed and dried first, and the plated part and lower half of the fixture are subsequently rinsed and dried.

It is contemplated that the use of one or more horizontal spargers 110 having holes/inlets 111 and being located at an end of a chamber 120 at least partially formed by an upper channel 122 and lower channel 121 to direct fluid flow through a first of the channels and towards a second channel so that it flows toward a part 900 positioned relative to a gap 131 between the channels as shown in figures 2 and 2A will provide for more turbulent fluid flow and a corresponding higher deposition rate. In order to obtain the desired turbulence, it is preferred that the distance D5 between the upper and lower channels (the width of gaps 131) be as low as 20 percent of the height D6 of work piece 900.

In essence, the shields 130 of figure 2 form narrow upper and lower plating channels (121 and 122) through which the parts being plated move with each part 900 having one edge 902 positioned within the upper plating channel 122 and an opposite edge 901 positioned within the lower plating channel 121. Because the shields 130 are electrically insulating, current flow between the work piece 900 and the anode baskets 140 is forced to pass through the gaps 131 between the upper and lower shields. Positioning and movement of a part 900 within channel 120 is accomplished by clipping part 900 to a clip 170 and moving clip 170.

Figure 3A shows the original design of the part holding clamps/clips 170A utilized by the system of figure 1 while figure 3B shows an improved clip 170 for use in the system of figure 2. It should be noted that the clamp design has been modified to permit the distance D2 between the shields and a work piece being held by the clamps to be decreased to 0.5 inches or less by decreasing the thickness D5 of clip 170.

It is contemplated that shielding the work piece/cathode of a plating system by moving the work piece within narrow channels formed by the shield rather than using the shields to shield the anodes by moving the shields closer to the anodes than to the parts being plated results in better distribution of deposited metal on the work pieces. As such, it contemplated that the distance D3 between the shields 130 and the anodes 140 be greater than the distance D2 between a part being plated 900 and the shields 130.

A method 1000 of using the system of figure 2 may include (see figure 4) the following steps: step 1010, submerging a work piece 900 to be plated in a volume of plating solution 800; step 1020, positioning the work piece to be plated 900 at least partially within an upper plating channel 122 and a lower plating channel 121, the upper and lower plating channels comprising non electrically conductive sides (shields 130), the channels 121 and 122 being positioned opposite each other and being separated from each other, the separation between the channels forming a pair of solution egress slots 131 positioned approximately over the center of the work piece 900 to be plated; step 1030, causing electrical current to flow between the work piece 900 and one or more anodes 140, the current flow passing through the solution egress slots 131; and step 1040, moving the work piece 900 to be plated along the length of the plating channels 121 and 122 to form an electrodeposited layer on one or more internal heat spreaders (911, 921). The surface (910, 920) of the work piece 900 is essentially parallel to the shields 130 during this operation.

The forgoing method may further comprise one or more of the following steps: step 1005, coupling the work piece to a frame adapted to hold and move the work piece during plating; step 1050, after plating, performing a first rinse and dry cycle wherein at least a portion of the frame is rinsed and dried while the work piece is kept damp; and step 1060, after the first rinse and dry cycle, performing a second rinse and dry cycle wherein the work piece is removed from inner cell 150 and rinsed and dried. It is contemplated that the use of such a two step process wherein the frame is dried first will result in stain free drying of the work piece bacause potentially contaminated rinsewater from the clip is not allowed to redeposit onto and/or stain the workpiece.

The following steps may also prove advantageous when used in the foregoing method: a) rinsing the workpiece/part and clip with clean water; b) drying only the clip without regard

for staining; c) rinsing the part only with ultra pure water, while keeping the clip dry; d) drying the part. This drying method prevents the possibility contaminated rinsewater from the clips splashing onto the parts during drying causing staining of the heat spreaders.

Variations of this method may include the use of channels having a width of one inch or less and/or including a step of adjusting the width of the slots 131 between the channels to obtain an optimum or at least more uniform plating distribution on the work piece 900.

In preferred embodiments, horizontal sparger 110 will be sized adequately to provide turbulent flow within the channel. Care must be taken to allow sufficient drainage such that the cell does not want to overflow. It is also difficult to achieve turbulent flow over the submerged portion of the clip while not allowing any splashing of the plating fluid onto the portion of the clips above the cell. Any solution that is splashed onto the clips contributes to the previously mentioned rinse-dry concerns.

Chamber 120 is preferred to allow for turbulent flow across the work piece while minimizing surface splashing. This is generally achieved by designing a discharge plenum (horizontal sparger 110) with a series of holes with a given diameter. These holes are drilled in such a manner to direct fluid toward the part contained within the clip. Plating solution is pumped through this plenum through a valve style restrictor, and this valve is adjusted to achieve the maximum flow without causing splashing at the surface of the plating solution. The distance between the discharge plenum and the part, the hole diameter of the discharge plenum and the flow rate through the plenum are all set to maximize turbulent flow at the workpiece while minimizing splashing at the solution surface.

Shields 120 preferably comprise a sheet of electrically insulating material in which a slot has been machined to allow current flow, the slot being centered on the part to be plated. The length of the slot should coincide with the length of the anode from which electrical current is being restricted, and the height of the slot is selected to provide the best metal distribution on the electroplated component. Empirically, a slot of about ¼" allows ample current for plating of a square heat spreader 1 ¼" on a side. In this example, the shield was moved to within ½" of the clip containing the part for plating.

In preferred embodiments, the solution velocity will be such that it is clearly within the region for turbulent flow. This is important in order to replenish plating electrolyte at the work surface, which is necessary to increase metallic deposition rate. Using the cell described above, deposition rates exceeding 2 microns/minute have been achieved when depositing nickel from sulfamate based electrolyte.

It is contemplated that system 100 is particularly well adapted for use with a metal electrolyte designed to deposit 800 one or more of the following metals: Ni, Au, Ag, Sn, Cu, Pb, In, Bi or alloys of these.

It is contemplated that system 100 may be advantageously used where work piece 900 comprises is one or more copper heat spreaders specifically designed to remove or dissipate heat from semiconductor devices. Althernately, the copper may be replaced with Aluminum, Aluminum-Silicon alloy, kovar alloy 42 or alloys thereof.

Use of the preferred system and or method is contemplated to result in deposition rates of at least 2 microns/minute while maintaining a uniform distribution of metal such that the thickness of the deposited metal varies by less than 1 micron over the surface of the work piece being plated. Sample 31 mm square heat spreaders electroplated with about 4 microns of nickel had a film uniformity of 3.5 microns to 4.5 microns across the part. Identical parts plated without the optimized shielding approach were typically 3 microns at the low point to over 6 microns at the high points.

Thus, specific embodiments and applications of an improved plating system have been disclosed. It should be apparent, however, to those skilled in the art that many more modifications besides those already described are possible without departing from the inventive concepts herein. The inventive subject matter, therefore, is not to be restricted except in the spirit of the appended claims. Moreover, in interpreting both the specification and the claims, all terms should be interpreted in the broadest possible manner consistent with the context. In particular, the terms "comprises" and "comprising" should be interpreted as referring to elements, components, or steps in a non-exclusive manner, indicating that the referenced elements, components, or steps may be present, or utilized, or combined with other elements, components, or steps that are not expressly referenced.

CLAIMS

What is claimed is:

1. A plating system comprising:
an elongated upper channel and an elongated lower channel; and
a plating solution sparger comprising a series of inlets oriented to direct any plating solution flowing through the inlets into one and towards another of the upper and lower channels.

2. The system of claim 1 further comprising:
an anode; and
a substantially planar cathode comprising a first surface conductive surface, a second conductive surface, and a perimeter edge, the first conductive surface and second conductive surfaces being substantially parallel to each other and positioned on opposite sides of the cathode; wherein
the sparger is positioned at least as close to the perimeter edge of the cathode as to either of the first or second conducting surfaces.

3. The system of claim 2 wherein the sparger directs any plating solution flowing through the inlets towards the cathode in a plane substantially coplanar with the cathode.

4. The system of claim 3 wherein:
each of the upper and lower channels comprises two substantially planar and parallel non electrically conductive sides that are substantially parallel to the cathode; and
the cathode is positioned at least partially within each of the upper and lower channels between the non electrically conductive sides.

5. The system of claim 4 wherein:
the upper and lower channels are positioned opposite each other and are separated from each other, the separation between the channels forming a pair of solution egress slots; and

the channels are adapted to prevent current from flow between the anode and cathode other than through the egress slots.

6. The system of claim 5 wherein the egress slots are positioned approximately parallel to a center line of the cathode.

7. The system of claim 6 wherein the cathode comprises a dielectric substrate and the conductive surfaces are adapted to promote the formation of heat spreaders on the dielectric substrate.

8. The system of claim 1 wherein each of the upper channel and lower channel have a width less than or equal to one inch.

9. The system of claim 1 wherein the sparger is positioned horizontally and directs any plating solution flowing through the inlets into the lower channel and towards the upper channel.

10. The system of claim 1 wherein each of the upper channel and lower channel have a width less than or equal to 0.5 inches.

11. The system of claim 1 wherein each of the upper channel and lower channel have a width less than or equal to 0.5 inches, and the further comprising a plurality of part holding clamps electrically coupled to a power source and positioned within the upper channel or the lower channel.

12. The system of claim 1 further comprising a plurality of anodes positioned outside and along the length of the upper and lower channels.

13. The system of claim 1 wherein the upper channel and lower channel are separated by a distance and at least one of the upper channel and lower channel are adapted to be moved to vary the distance.

14. The system of claim 1 wherein the shortest distance from a part being plated to a channel wall is less than the shortest distance between the channel wall and an anode.

15. A plating system comprising:

an anode, a planar cathode, a sparger, and a plurality of electrically insulating shields; wherein

each of the plurality of shields is positioned between the anode and the cathode but not between the sparger and the cathode, and each of the plurality of shields is approximately co-planar with one of two reference planes that are substantially parallel to the cathode; and

the sparger is adapted to direct plating fluid toward and edge of the cathode along in a plane substantially co-planar with cathode.

16. A method of plating a work piece comprising:

submerging a work piece to be plated in a volume of plating solution;

positioning a work piece to be plated at least partially within an upper plating channel and a lower plating channel, the upper and lower plating channels comprising non electrically conductive sides, the channels being positioned opposite each other and being separated from each other, the separation between the channels forming a pair of solution egress slots positioned approximately over the center of the work piece to be plated;

causing electrical current to flow between the work piece and one or more anodes, the current flowing into the upper and lower channels only after passing through the solution egress slots; and

moving the work piece to be plated along the length of the plating channels to form one or more internal heat spreaders on a surface of the work piece which is essentially parallel to the shields.

17. The method of 16 further comprising:

coupling the work piece to a frame adapted to hold and move the work piece during plating;

after plating, performing a first rinse and dry cycle wherein at least a portion of the frame is rinsed and dried while the work piece is kept damp;

after the first rinse and dry cycle, performing a second rinse and dry cycle wherein the work piece is rinsed and dried.

18. The method of claim 17 wherein water is used in the first and second rinse cycles, and the second rinse cycle utilizes water having fewer impurities than that used in the first rinse cycle.

AMENDED CLAIMS

[received by the International Bureau on 22 July 2002 (22.07.02); original claims 1-18 replaced by amended claims 1-18 (4 pages)]

What is claimed is:

1. A plating system comprising:

at least two anodes;

an elongated upper channel and an elongated lower channel, each of the upper and lower channels positioned between the at least two anodes and each of the channels comprising at least two insulating sides; and

a plating solution sparger comprising a series of inlets oriented to direct any plating solution flowing through the inlets into one and towards another of the upper and lower channels.

2. A plating system comprising:

an elongated upper channel and an elongated lower channel;

a plating solution sparger comprising a series of inlets oriented to direct any plating solution flowing through the inlets into one and towards another of the upper and lower channels;

an anode; and

a substantially planar cathode comprising a first surface conductive surface, a second conductive surface, and a perimeter edge, the first conductive surface and second conductive surfaces being substantially parallel to each other and positioned on opposite sides of the cathode; wherein

the sparger is positioned at least as close to the perimeter edge of the cathode as to either of the first or second conducting surfaces.

3. The system of claim 2 wherein the sparger directs any plating solution flowing through the inlets towards the cathode in a plane substantially coplanar with the cathode.

4. The system of claim 3 wherein:

each of the upper and lower channels comprises two substantially planar and parallel non electrically conductive sides that are substantially parallel to the cathode; and

the cathode is positioned at least partially within each of the upper and lower channels between the non electrically conductive sides.

5. The system of claim 4 wherein:

the upper and lower channels are positioned opposite each other and are separated from each other, the separation between the channels forming a pair of solution egress slots; and

the channels are adapted to prevent current from flow between the anode and cathode other than through the egress slots.

6. The system of claim 5 wherein the egress slots are positioned approximately parallel to a center line of the cathode.

7. The system of claim 6 wherein the cathode comprises a dielectric substrate and the conductive surfaces are adapted to promote the formation of heat spreaders on the dielectric substrate.

8. The system of claim 1 wherein each of the upper channel and lower channel have a width less than or equal to one inch.

9. The system of claim 1 wherein the sparger is positioned horizontally and directs any plating solution flowing through the inlets into the lower channel and towards the upper channel.

10. The system of claim 1 wherein each of the upper channel and lower channel have a width less than or equal to 0.5 inches.

11. The system of claim 1 wherein each of the upper channel and lower channel have a width less than or equal to 0.5 inches, and the further comprising a plurality of part holding clamps electrically coupled to a power source and positioned within the upper channel or the lower channel.

12. The system of claim 1 further comprising a plurality of anodes positioned outside and along the length of the upper and lower channels.

13. The system of claim 1 wherein the upper channel and lower channel are separated by a distance and at least one of the upper channel and lower channel are adapted to be moved to vary the distance.

14. The system of claim 1 wherein the shortest distance from a part being plated to a channel wall is less than the shortest distance between the channel wall and an anode.

15. A plating system comprising:

an anode, a planar cathode, a sparger, and a plurality of electrically insulating shields; wherein

each of the plurality of shields is positioned between the anode and the cathode but not between the sparger and the cathode, and each of the plurality of shields is approximately co-planar with one of two reference planes that are substantially parallel to the cathode; and

the sparger is adapted to direct plating fluid toward an edge of the cathode in a plane substantially co-planar with the cathode.

16. A method of plating a work piece comprising:

submerging a work piece to be plated in a volume of plating solution;

positioning a work piece to be plated at least partially within an upper plating channel and a lower plating channel, the upper and lower plating channels comprising non electrically conductive sides, the channels being positioned opposite each other and being separated from each other, the separation between the channels forming a pair of solution egress slots positioned approximately over the center of the work piece to be plated;

causing electrical current to flow between the work piece and one or more anodes, the current flowing into the upper and lower channels only after passing through the solution egress slots; and

moving the work piece to be plated along the length of the plating channels to form one or more internal heat spreaders on a surface of the work piece which is essentially parallel to the shields.

17. The method of 16 further comprising:

coupling the work piece to a frame adapted to hold and move the work piece during plating;

after plating, performing a first rinse and dry cycle wherein at least a portion of the frame is rinsed and dried while the work piece is kept damp;

after the first rinse and dry cycle, performing a second rinse and dry cycle wherein the work piece is rinsed and dried.

18. The method of claim 17 wherein water is used in the first and second rinse cycles, and the second rinse cycle utilizes water having fewer impurities than that used in the first rinse cycle.

IN THE INTERNATIONAL BUREAU (WIPO)

International Application Number	International Filing Date	International Earliest Priority Date
PCT/US02/05536	**21 February 2002**	**02 March 2001**

Title of Invention: **Internal Heat Spreader Plating Methods and Devices**
Applicant: **Honeywell International, Inc.**

International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20
Switzerland

LETTER FOR PCT ARTICLE 19 (PCT SECTION 205)

1. Applicant herewith submits replacement sheets(s) number(ed) **8-11** to replace sheet(s) number(ed) **8-11** originally filed for this application.

2. In respect of each claim appearing in the international application based on the replacement sheets submitted herewith, and in accordance with PCT Section 205, the following claim(s) is/are:

(i) unchanged: claim(s) **3-14, 16-18**
(ii) cancelled: claim(s) **0**
(iii) new: claim(s) **0**
(iv) replacement of one or more claims as filed, as follows: **1, 2, 15**
(v) the result of the division of one or more claims as filed, as follows: **0**

Respectfully submitted,

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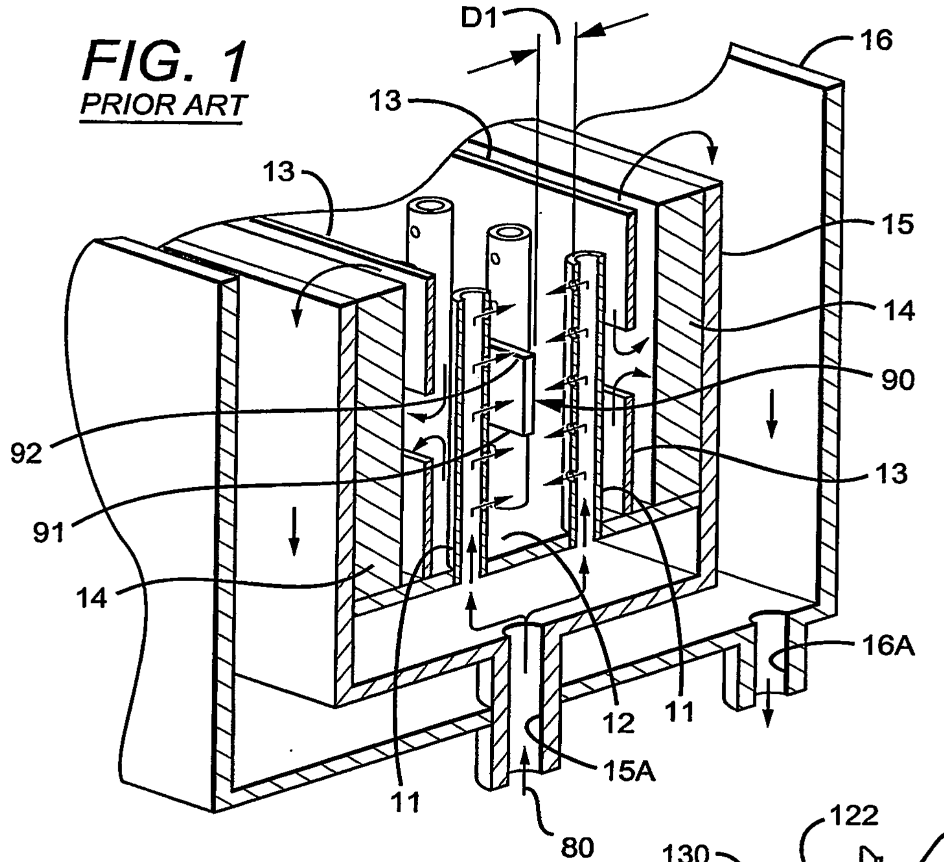
298795.01 a07/02/02

FIG. 1
PRIOR ART



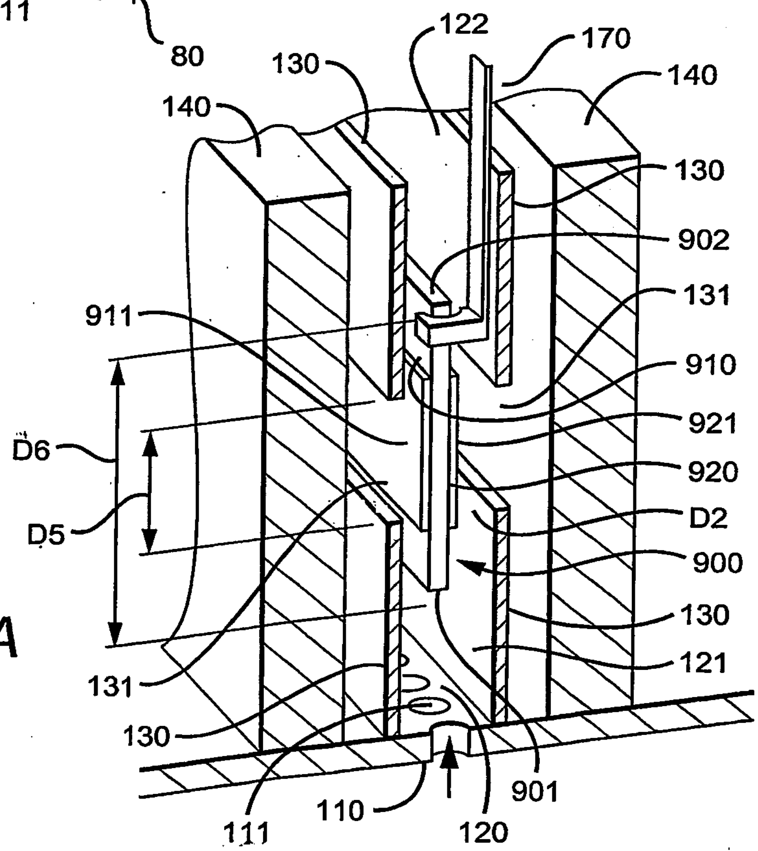


FIG. 2A

FIG. 2

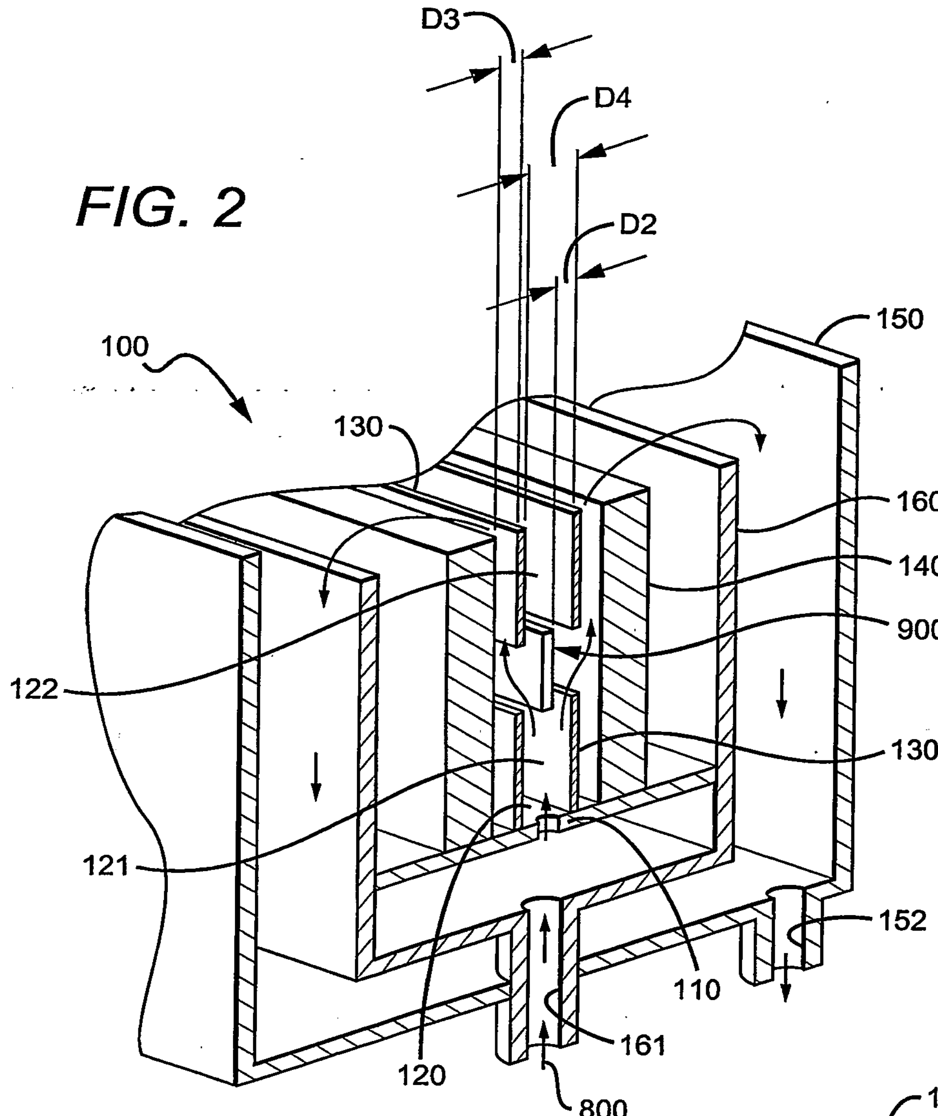


FIG. 3A

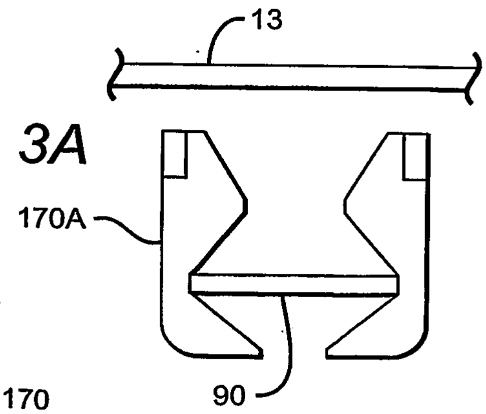
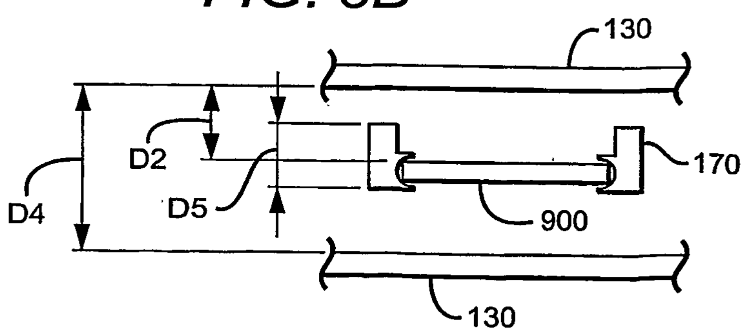


FIG. 3B



1005 COUPLING A WORK PIECE TO FRAME ADAPTED TO HOLD AND MOVE THE WORK PIECE DURING PLATING

1010 SUBMERGING THE WORK PIECE TO BE PLATED IN A VOLUME OF PLATING SOLUTION

1020 POSITIONING THE WORK PIECE TO BE PLATED AT LEAST PARTIALLY WITHIN AN UPPER PLATING CHANNEL AND A LOWER PLATING CHANNEL, THE UPPER AND LOWER PLATING CHANNELS COMPRISING NON ELECTRICALLY CONDUCTIVE SIDES, THE CHANNELS BEING POSITIONED OPPOSITE EACH OTHER AND BEING SEPARATED FROM EACH OTHER, THE SEPARATION BETWEEN THE CHANNELS FORMING A PAIR OF SOLUTION EGRESS SLOTS POSITIONED APPROXIMATELY OVER THE CENTER OF THE WORK PIECE TO BE PLATED

1030 CAUSING ELECTRICAL CURRENT TO FLOW BETWEEN THE WORK PIECE AND ONE OR MORE ANODES, THE CURRENT FLOW PASSING THROUGH THE SOLUTION EGRESS SLOTS

1040 MOVING THE WORK PIECE TO BE PLATED ALONG THE LENGTH OF THE PLATING CHANNELS TO FORM ONE OR MORE INTERNAL HEAT SPREADERS ON A SURFACE OF THE WORK PIECE WHICH IS ESSENTIALLY PARALLEL TO THE SHIELDS

1050 AFTER PLATING, PERFORMING A FIRST RINSE AND DRY CYCLE WHEREIN AT LEAST A PORTION OF THE FRAME IS DRIED WHILE THE WORK PIECE IS KEPT DAMP

1060 AFTER THE FIRST RINSE AND DRY CYCLE, PERFORMING A SECOND RINSE AND DRY CYCLE WHEREIN THE WORK PIECE IS REMOVED FROM THE INNER CELL AND RINSED AND DRIED

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US02/05536

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : B05C 3/00, 3/02; C25D 17/00, 5/00, 7/06
US CL : 118/410, 429; 204/273, 275.1; 205/137, 138;
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 118/410, 429; 204/206, 211, 273, 275.1; 205/137, 138;

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST: Sparger; electroplating, channels

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,372,825 A (EIDSCHUN) 08 February 1983, col. 3-4.	1, 8, 12
Y	US 4,772,371 A (LACE et al) 20 September 1988, Figures 2 and 3, col. 3, lines 35-68; col. 4 lines 32-68.	1, 12
Y	US 4,534,832 A (DOIRON, JR.) 13 August 1985, col. 3-4 and Figures.	1, 12-13
A	US 4,443,304 A (EIDSCHUN) 17 April 1984.	

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 22 MAY 2002	Date of mailing of the international search report 17 JUN 2002
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer DONALD R. VALENTINE Telephone No. (703) 308-0661

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60/272,805 2 March 2001 (02.03.2001) US

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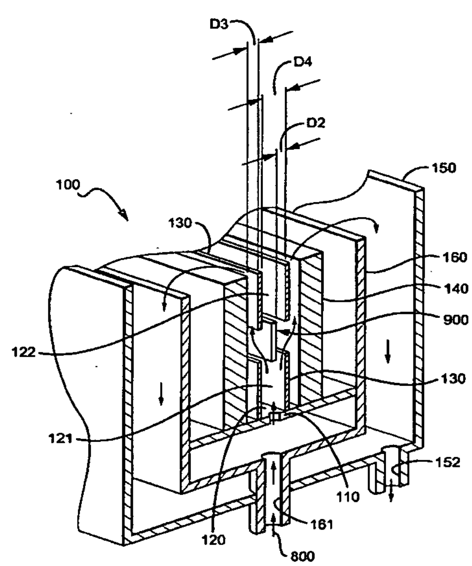
(81) Designated States *(national)*: AE, AG, AL, AM, AT (utility model), AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ (utility model), CZ, DE (utility model), DE, DK (utility model), DK, DM, DZ, EC, EE (utility model), EE, ES, FI (utility model), FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: INTERNAL HEAT SPREADER PLATING METHODS AND DEVICES



(57) Abstract: An improved method and plating system (100) comprising a plurality of non-electrically conductive shields (130) forming an elongated upper channel (122) and an elongated lower channel (121); a plating solution sparger comprising a series of inlets oriented to direct any plating solution flowing through the inlets into the lower channel and towards the upper channel; a plurality of anodes positioned outside and along the length of the upper and lower channels; said method comprising submerging a workpiece (900) in the plating solution; positioning the workpiece at least partially within the channels, and causing electrical current to flow between the anodes the workpiece moving along the channel lengths.

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— *with amended claims*

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Previous Correction:
see PCT Gazette No. 12/2003 of 20 March 2003, Section II

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.